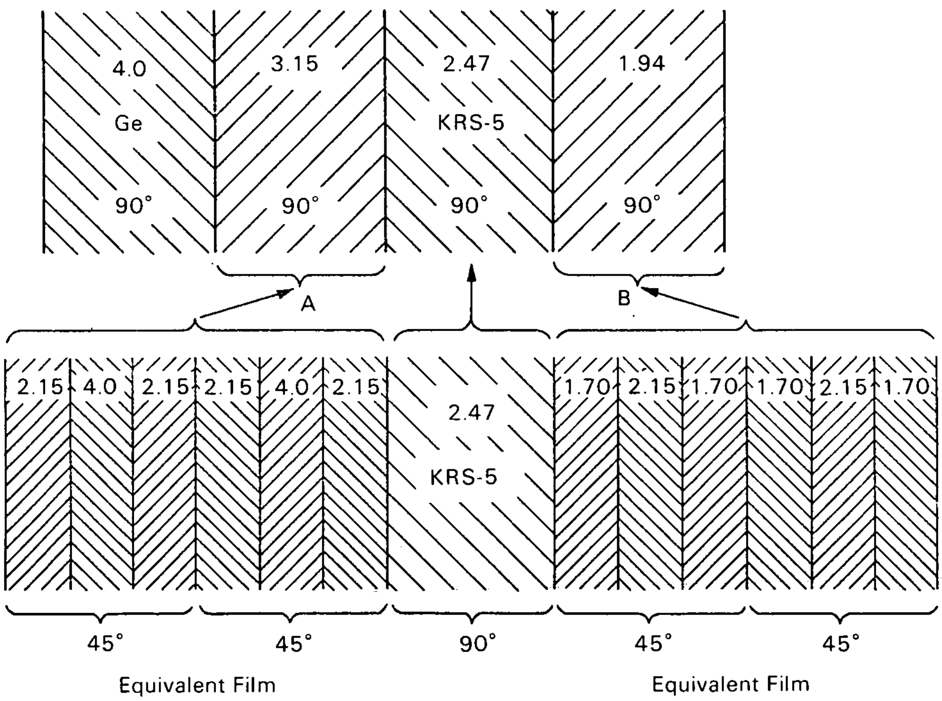
August 1969 Brief 69-10260

NASA TECH BRIEF

Multilayer Infrared Beamsplitter Film System



Construction of Multilayer Film Stack

Industries concerned with optical coating, vacuum deposition, radiometry, interferometry, and spectrometry should be interested in this multilayer infrared beamsplitter film system. The system on a potassium bromide crystal substrate is operational over the wavelength range of 2.5 to 25 microns with nearly equal broadband reflectance and transmittance between this range. A dual purpose of substrate protection against humidity as well as optical performance is served by the films chosen.

The exponentially step-graded index type beamsplitter thin film design is of high efficiency permitting spectral resolution over a broad frequency range (10 to 1) with a single compact, lightweight element. Beamsplitter systems of other designs are of lower efficiency requiring multiple elements and instruments to cover the same frequency range.

In developing the infrared coating design, reflectance versus wavelength was computed for several film designs. Required indexes for a three-film system were

(continued overleaf)

3.15, 2.47, and 1.94. KRS-5 (TlBr-TlI) film satisfied the 2.47 index requirement, but the other two films were not available. The method of L. I. Epstein (J. Opt. Soc. Am. **42:** 806, 1952) and P. H. Berning (J. Opt. Soc. Am. **52:** 431, 1962) was used to design an equivalent film system having the required indexes and optical thicknesses. Computed curves of reflectance versus wavelength for a three-film system and a thirteen-layer Herpin-equivalent-index film were plotted. Agreement between these curves was satisfactory.

The thirteen-layer system was designed as follows:

Air	*Stack A*	
1.0	H+ (.166M, .166H, .332M, .166H, .166M) +	
	Stack B	*Substrate*
K + (.166L, .166M, .332L, .166M, .166L)		1.53

where H, M, K, and L represent films of one quarter (90°) wave optical thickness at 5.0 microns. The films and their indexes are:

H (Ge):	4.00
M (TlBr):	2.15
K (KRS-5 (TlBr-TlI)):	2.47
L (PbF_2):	1.70

Stack A consists of two symmetrical periodic structures with equivalent index 3.15 and phase thickness 90°. Stack B consists of two symmetrical periodic structures with equivalent index 1.94 and phase thickness 90°. The design is illustrated in the drawing.

Computed and experimental curves of reflectance versus wavelength for the thirteen-layer Herpin-equivalent index systems were plotted, and agreement between these curves was good.

Attempts at making equivalent index systems of more than 13 films were unsuccessful; apparently the system becomes mechanically unstable above 13 films.

A film coating was developed to protect the KBr beamsplitter and compensator substrates against humidity, while affecting the infrared beamsplitter performance as little as possible in the operational range. The coating consisted of a quarter-half-quarter wave optical thickness stack respectively of PbF_2, ZnS, and $ThOF_2$. Design wavelength was 0.6 micron where antireflection occurs. The coating was able to withstand 70 ±3% relative humidity at 30°C for 24 hours.

Note:

Documentation is available from:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland 20771
Reference: TSP69-10260

Patent status:

No patent action is contemplated by NASA.

Source: R. C. Bastien and P. L. Heinrich of
Perkin-Elmer Corporation
under contract to
Goddard Space Flight Center
(XGS-11036)